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Tot onze diepe droefheid overleed heden onze lieve Vader, Behuwd- en Grootvader

Albert Jan KLUYVER

Hoogleraar aan de Technische Hogeschool
Oud-Voorzitter van de Koninklijke Akademie van Wetenschappen
Ridder in de Orde van de Nederlandse Leeuw

op de leeftijd van 67 jaar.

AMSTERDAM	A. SIEPMAN van den BERG—KLUYVER J. J. SIEPMAN van den BERG
LIVERPOOL	J. C. KLUYVER
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SALISBURY (Southern Rhodesia)	C. Th. KLUYVER J. W. KLUYVER—van LEUSEN
LEIDEN	C. A. KLUYVER

en kleinkinderen.

Delft, 14 Mei 1956.
Nieuwe Laan 3.

Liever geen toespraken.

De verassing is bepaald op Vrijdag 18 Mei a.s. in het Crematorium te Velsen, na aankomst van trein 12.02 halte Driehuis-Westerveld.

This notice of the passing of Prof. Dr. Albert Jan Kluyver, has saddened the whole fraternity of microbiologists. A review of this life and work in his chosen field will be included in the October, 1956, issue of this BULLETIN.

(Page 97)

INTERNATIONAL BULLETIN OF BACTERIOLOGICAL NOMENCLATURE AND TAXONOMY
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STAPHYLOCOCCUS AUREUS VERSUS STAPHYLOCOCCUS PYOGENES

S. T. Cowan

National Collection of Type Cultures
London, England

Dr. Breed (1) has presented a strong case for the use of Staphylococcus pyogenes as the specific name of the type of Staphylococcus Rosenbach, and has asked the Judicial Commission not only to accept Staphylococcus pyogenes as the name for the type but also to waive the Code's requirement that the first variety of S. pyogenes should be S. pyogenes var. pyogenes. Dr. Breed would create three varieties based presumably on differences in pigmentation. Nearly all workers except the Winslows have rejected pigmentation as a basis for classifying staphylococci and those who are more familiar with these organisms know that the variety aureus is so unstable that, even when freshly isolated, it continually throws a high proportion of so-called albus variants. It would indeed be poor systematics to have a variety which was continually changing to another variety. The third, or variety citreus is rather different; my experience of coagulase-positive staphylococci which produce a lemon-yellow pigment is that they are much more stable than the gold-pigmented strains. But pigmentation is so unsatisfactory for the classification of staphylococci that Staphylococcus aureus is defined by nearly all recent workers on the basis of the coagulase test, and pigmentation is ignored.

The binomial Staphylococcus pyogenes has been attributed to Rosenbach, who never used it, and in fact Dr. Breed tells us on page 39 (1) that Passet was the first author to use Staphylococcus pyogenes "without an attached varietal name". Consequently, if in the next edition of the Bergey Manual the name Staphylococcus pyogenes is used, it should be attributed to Passet and not to Rosenbach.

Locke wrote in the seventeenth century that "genus and species of things (for those Latin terms signify to me no more than the English word sort)" and even today to most people the word "species" has the meaning of sort, so that no difference is made to the sense of Rosenbach's phrase by

interpreting the German word Art as "sort" instead of "species". There is no concensus of opinion on what constitutes a bacterial species, and it is most unlikely that Rosenbach gave any thought to whether he was dealing with sorts, species, or varieties. What is important is that our interpretation of his writings should be in conformity with the Rules of the Bacteriological Code.

Staphylococcus aureus was correctly used by Rosenbach in his book published in 1884, and no amount of discussion can get around that fact. Staphylococcus pyogenes is a later synonym, and can only be made the correct name by action of the Judicial Commission.

Some workers believe that Staphylococcus pyogenes has been used in the literature more than Staphylococcus aureus. In the absence of a detailed list of all papers using binomials for staphylococci it is a matter of opinion which binomial has been most used; personally I think that the popularity of Staphylococcus pyogenes has been greater in biochemical than in bacteriological journals. But popularity has no place in bacteriological nomenclature and Rule 23 is quite firm in its prohibition of a change of a validly published epithet to one that is "better known".

It is now time that the Judicial Commission should be asked to give an Opinion on the proposal by Gibson (2) and the amendments made by others (1, 3). The facts and various personal interpretations have already been put forward; an official Opinion will settle which epithet is to be used by those who observe the Rules of the Bacteriological Code and the Opinions issued by the Judicial Commission.

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INTERNATIONAL BULLETIN OF BACTERIOLOGICAL NOMENCLATURE AND TAXONOMY
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VERBAL STEMS IN LATIN COMPOSITION

R. E. Buchanan

The use of Latin verbal stems in formation of modern Latin specific epithets in species names is a continuing source of perplexity to those dealing with biological nomenclature. Are compound words having a verbal stem as the final component to be identified as adjectives or as nouns? A review of classical and modern uses of the Latin verbal stem col derived from the verb colo (to dwell, to inhabit) will illustrate. In modern Latin are found compound specific epithets which have -cola, definitely regarded as a noun ending, as the last component; others in which the ending is adjectival in form, often with the neuter ending (-colum). It is contended, since there is no classic Latin precedent for formation of such adjectival compounds of col-, that words adjectival in form should be corrected to nouns ending in -cola. This view is widespread among botanists. It may be illustrated by a quotation from Wakefield and Moore (1):

> "With regard to the species of Myxosporium causing canker of apple, since the mistake is so often made, it seems desirable to point out that the specific epithet should be corticola and not corticolum, as was wrongly used by Edgerton. Latin words ending in -cola, as incola, agricola, terricola are not adjectives but nouns of common gender, formed from the stem col-. There is no corresponding adjectival form. The specific epithet corticola is thus a noun in apposition, meaning an inhabitant of the bark; it cannot be declined like an adjective."

This point of view agrees with the opinion of many botanists, who regard the formation of compound adjectives with endings -colus, -cola, or -colum as solecisms which should be corrected.

Classic Latin precedent should be determined. Gradenwitz, in his Laterculi vocum latinarum (1904) lists 40 Latin words which end in -cola; all are nouns of masculine or common gender. No Latin words with the stem col end in -colus or -colum.

Several questions should be answered.

1. How consistently have biologists, in compounding specific epithets, followed the Latin precedent of using the verbal stem col only as -cola to form masculine or common gender nouns? A study of 1006 microbiological specific epithets which included the verbal stem col in the final component reveals the following:

a. Specific epithets ending in -cola associated with feminine generic names. Inspection in this case cannot determine whether the specific epithet is a noun in apposition or a modifying adjective, there is no difference in spelling; 775 specific epithets of the total 1006 are in this class and cannot be identified by observation.

b. Specific epithets ending in -cola associated with masculine or neuter generic names. These are, of course, nouns in apposition; 117 of the total number of epithets studied belong here.

c. Specific epithets ending in -colus or -colum. Two epithets ending in -colus following masculine generic names and 112 ending in -colum following neuter names were definitely indicated as adjectives by their authors. A total of 114 epithets appear in this category.

In summary, of the 231 identifiable specific epithets, about half (117) could be recognized definitely as nouns, and half (114) as adjectives. The list was from names of microorganisms only (fungi, algae, and bacteria), with no ferns or flowering plants. In all but two cases the adjectival specific epithets were neuter.

It is evident that in fields such as mycology, the Latin precedent of always forming nouns ending in -cola to be used as specific epithets has been frequently disregarded.

2. Should the adjectives ending in -colus and -colum be regarded as solecisms to be corrected to nouns ending in -cola? Several items should be considered.

a. The custom of using the adjectival form seems well

established, particularly with neuter generic names. It is evident that the adjectival form, rather than the noun, has been chosen deliberately. The suggestion made by one philologist that the use of the adjectival forms -colus, -cola, -colum may be due to confusion with the diminutive endings -culus, -cula, -culum displays an unwarrantedly gloomy view of biological Latin and can be dismissed as wholly improbable. It has also been suggested that many of the adjectives originated with Saccardo and are to be regarded as "the coinage of one notoriously inept in his Latin."

b. All nomenclatural codes forbid a change in spelling except in a clear case of a lapsus or an unintentional orthographic error. There is no code provision that classic usage for each verbal stem must be followed. There seems to be no legal warrant for correction, even though such may be assumed as necessary by some workers.

Very commonly Latin verbal stems other than col are used in the construction of modern Latin specific epithets. This custom is well explained by Clements (2) in his analysis of the formation of compounds from Latin stems. He says of such compounds:

"If the last term is a verbal stem, the compound may be a noun of the first or third declension, or an adjective of three terminations or one termination."

Clements clearly recognized the formation of both nouns and adjectives from any Latin verbal stem as legitimate.

In modern languages having large Latin content, as English, the Latin verbal stem is regularly used in formation of adjectives derived from the Latin, as in arenicolous, limicolous, lignicolous, and silvicolous. It may be contended that to forbid the formation of similar modern Latin adjectives may be quite unrealistic.

2. Do the same problems noted above, arise when verbal stems other than col are employed in forming modern Latin compounds to be used as specific epithets? Did the Latins treat all verbal stems in the same manner? Several such

stems may be examined, some used extensively by the Latins as well as in modern word formation. The following additional verbal stems will be noted: ceps, cid, fer, fex, fic, frag, fug, gen, ger, par, vag, and vor. It is believed that this list constitutes a representative sample. The data with reference to use of these verbal stems are taken largely from the "Laterculi" of Gradenwitz.

Ceps, cipis from capio (to take into possession, to accept)

Masculine nouns as manceps (hand taker, purchaser) and adjectives with a single ending as princeps (first taken, first) were used by the Latins. Such words were rather rarely formed, perhaps because of the confusion with nouns and adjectives ending in -ceps, -cipitis derived from the noun caput, capitis, the head. Two adjectives only, ending in -ceps, -cipis, have been found among modern microbiological specific epithets, princeps and pseudoprinceps. All other specific epithets ending in -ceps have cipitis in the genitive, and are derived from caput. Of these, 65 are adjectives, one is a noun.

Cid from caedo (to cut, to kill)

There is 1 masculine Latin noun ending in -cidus (muricidus mouse killer, coward); and 16 masculine or common Latin nouns ending in -cida (as matricida mother killer), There are no Latin adjectives ending in -cidus, -cida, -cidum. Perhaps such were avoided because of the existing adjectives with which they might be confused, such as acidus, lucidus derived from other stems.

A total of 26 words used as specific epithets in composition of modern Latin specific epithets have as a final component an ending derived from cid. Of these, 13 end in -cida and are associated with feminine generic names; whether these are intended to be nouns or adjectives cannot be determined. Nine end in -cida and are used with masculine or neuter generic names; these specific epithets are definitely labeled as nouns. Two end in -cidus (with a masculine generic name) and two in -cidum (with a neuter generic name) and seem definitely to be intended as adjectives. Usage both in classic and in modern Latin seems to emphasize the formation of nouns of masculine or common gender ending in

-cidus, -cida, or -cidum. This usage closely parallels that of -cola.

Fer from fero (to bear, carry)

Gradenwitz lists 193 Latin words which have fer in the last component. All but three are adjectives with three endings, -fer (or -ferus), -fera, -ferum. Three feminine nouns end in -fera, i.e., flabellifera, conifera, and profera. In a list of 240 modern Latin specific epithets with a final component derived from fer, 45 end in -fer and 5 in -ferus following masculine generic names, and 53 in -ferum following neuter generic names. It is possible that some of these specific epithets may be interpreted as nouns, but self-evidently modern usage is quite definitely in accordance with Latin precedent, i.e., compounds formed from the verbal stem fer are usually adjectives. However, there are 2 cases in which specific epithets ending in -fer follow neuter nouns (as in Triceratium rotifer) and 2 in which words ending in -fera follow neuter nouns; such specific epithets may be regarded as nouns. Biological custom is quite definitely oriented to formation of adjectives from the verbal stem fer.

Fex, ficis from facio (to make, to produce)

Twenty-two Latin nouns end in -fex, all with the meaning of maker or producer. There are no adjectives. Two modern Latin specific epithets have been noted, flaccidifex and spinifex. They may be regarded either as nouns or adjectives. Spinifex, Tubifex, and Pontifex are among generic names recognized.

Fic from facio (to make, to produce)

One hundred and one Latin adjectives end in -ficus, fica, ficum and 7 Latin nouns end in -fica. Of 13 specific epithets in modern Latin, all may be regarded as adjectives, 3 ending in -ficus, 6 in -fica, and 4 in -ficum. In microbiology, particularly in bacteriology, the participial form -ficans seems to have preference, 16 specific epithets with this ending have been noted.

Frag from frango (to break)

Three Latin nouns end in -fraga (calcifraga, ossifraga, and saxifraga). One Latin noun ends in -fragus (ossifragus). Eight Latin adjectives end in -fragus, -fraga, or -fragum. Of 4 specific epithets in modern Latin, three are neuter adjectives; one following a feminine generic name ends in -fraga and may be regarded either as a feminine noun or an adjective.

Fug from fugio (to flee)

There are 13 Latin nouns which end in -fuga, as lucifuga (one who shuns light), and profuga (a refugee, a fugitive). Latin nouns ending in -fuga have common or masculine gender. Four Latin adjectives end in -fugus, -fuga, -fugum, as lucifugus (light shunning) or profugus (banished, fugitive). Among 6 specific epithets, one adjective, solifugus, can be identified, as also the noun transfuga. The remaining 4 end in -fuga and may be regarded either as nouns or adjectives.

Gen from gigno (geno) (to beget, to bear, to produce)

There is also the Greek stem gen (from genneo to beget, to bear, to produce) to be found in many Greek words. The Latin stem appears in the last component of compounds in the form of the adjective endings -genus, -gena, -genus or as the noun ending -gena. The Greek stem usually appears in adjectives ending in -genēs, -genēs, -genĕs and in nouns ending in -genēs. Three words in Harper's Latin dictionary which end in -genes (primigenes, trigenes, and monogenes) are taken from the Greek.

There are 32 Latin adjectives ending in -genus, -gena, -genum and 37 Latin nouns which end in -gena. There are no Greek words ending in -genus (-genos). There are 199 Greek adjectives (Buck and Peterson (4)) which end in -genes.

In a list of 177 specific epithets ending in -genes, -gena, -genum of Latin derivation, 175 are probably adjectives, 2 are nouns ending in -gena. Of the 175 adjectives, 99 are compounds in which the first component has a Latin stem, and 76 a Greek stem. Of the 73 adjectives ending in -genes, 55 have first components with Greek stems and 18 with Latin stems.

While in classic Latin adjectives from the verbal stem gen in the final component end in -genus, -gena, or genum, and while in classic Greek, adjectives from the stem gen in the final component end in -genes, little attention has been paid to classic usage in the formation of modern Latin specific epithets, and both Latin and Greek suffixes have been added to Latin and to Greek stems.

Ger from gero (to carry, to bear)

Not all Latin words ending in -ger are derived from -gero. Nearly all with the verbal stem -ger end in -iger. Of these, about ninety adjectives end in -ger (2 in -gerus), -gera, -gerum. Several nouns end in -ger. Of 87 specific epithets noted from the verbal stem -ger, 14 are adjectives ending in -ger, 4 in -gerus, 50 in -gera, and 19 in -gerum. No nouns ending in -gera are noted with certainty.

Par from pario (to bring forth, to bear)

Eight Latin adjectives end in -parus, para, parum, and 3 Latin nouns in -para. Of 12 specific epithets noted, all are probably adjectives ending in -parus, -para, -parum, though some of the 6 ending in -para might be interpreted as nouns.

Vag from vagor (to ramble, to wander)

There are 23 Latin adjectives ending in -vagus, -vaga, -vagum. No Latin nouns end in -vaga. Of 5 modern Latin specific epithets noted, none is a noun ending in -vaga, 1 is an adjective ending in -vagus, 2 adjectives end in -vaga and 2 in -vagum.

Vor from voro (to devour)

Three Latin adjectives end in -vorus, -vora, -vorum (as carnivorus flesh-eating). Of 39 modern Latin specific epithets, 9 are adjectives, ending in -vorus, 19 ending in -vora are probably adjectives, possibly nouns in part, 11 end in -vorum and are adjectives.

A sampling of compound verbal nouns and adjectives from Latin and modern Latin (specific epithets) suggests the following:

1. The Latins formed compounds adjectives and nouns in which the final components were derived from many verbal stems.

2. From the verbal stems col and cid they uniformly derived nouns ending in -cola or -cida. However, in modern Latin there are many specific epithets including col or cid which were definitely fixed by their authors as nouns, in other cases as adjectives. Is the adjectival ending to be regarded as an orthographic error and corrected? Among botanical nomenclators dealing with higher plants there is a tendency to change all such adjectives (even hundreds in number) to nouns conforming to Latin precedent, to treat adjectives as solecisms or unintentional orthographic errors and to correct them. For example, it is urged that all specific epithets which end in -colum (of which there are many among the fungi) and agree as adjectives with the neuter generic name should be corrected to nouns ending in -cola in apposition with the generic name. Are such changes warranted?

3. In use of most other important verbal stems (as fer, fic, frag, fug, gen, ger, par, vag, vor) in the final components of compounds, the Latins developed both adjectives and nouns in the fashion outlined by Clements, forming nouns of the first or third declension or adjectives of three terminations or one termination.

4. In classic Latin there appears to have been no rule consistently applied to determine whether compounds formed with a verbal stem in the last component are to be treated as adjectives or nouns. From some verbal stems custom dictated that only nouns should be formed, from some others predominantly adjectives, from others both nouns and adjectives. In coining new epithets or in recognizing old epithets formed from verbal stems, must the classic treatment of each verbal stem be recognized, or may one form epithets from all verbal stems either as nouns or adjectives?

5. The Botanical and the Bacteriological Codes clearly state that changes should not be made in the spelling of words when the spelling used was the clear intent of the author.

6. The extent to which changes would be required in words which in microbiological literature show clear departure from classic precedent may be well illustrated by consideration of modern Latin words which have in the final component the verbal stem gen. The Latins invariably used the endings -genus, -gena, and -genum in formation of adjectives, the Greeks as consistently used -genēs, -genēs, and genēs in the formation of Greek adjectives. Classically, -genus, -a, -um should be used in formation of adjectives from Latin stems and -genēs, -ēs, -ĕs for adjectives from Greek stems. However, the endings in practice are used quite interchangeably, both forms with either Greek or Latin first components.

7. Various proposals may be made to end misunderstanding and to further uniformity.

a. It might be ruled that each modern Latin compound specific epithet including a verbal stem in the last component shall end in a, be regarded as a masculine or common noun in apposition with the generic name. This would be consistent with classic Latin usage for a few verbal stems such as col and cid but would be clearly inconsistent with classic usage for use of most other Latin verbal stems.

b. It might be ruled that all such words should be regarded as adjectives agreeing with the generic name in gender. This would be inconsistent with classic usage which recognizes both nouns and adjectives.

c. It might be ruled that for each verbal stem classic usage should be determined and followed. This logically should be the point of view of those who insist that Latin precedent forbids the use of the adjectival endings -colus, -cola, -colum. This would mean that for guidance in nomenclature a tabulation of verbal stems would be necessary indicating for each whether nouns, adjectives, or both may be formed.

d. Clement's recommendation might be approved, to the effect that in forming or using modern Latin specific epithets with verbal stems in the last component, the author is free to employ them as nouns or adjectives without regard to the specific Latin precedents for each verbal stem. This conforms reasonably well to current practice.

e. It might be ruled that when a specific epithet is first used by an author in a binary combination with clear indication as to whether it is a noun or an adjective, the decision of the author shall be binding. For example, if an organism is first named Bacillus radicicola the word radicicola is fixed as a noun. If the status of the specific epithet is not fixed by first usage, whether it is an adjective or noun is to be determined by the first subseqneut author who in transferring to another genus finds a decision necessary.

There is no firm agreement in biology as to the "part of speech" resulting from the use of Latin verbal stems in the coining of new compound specific epithets. Is it not possible that a common decision could be reached by agreement among bacteriologists, botanists, and zoologists?

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THE RELATIONSHIPS BETWEEN CERTAIN MEMBERS OF THE STAPHYLOCOCCUS-MICROCOCCUS GROUP AS SHOWN BY THEIR CELL WALL COMPOSITION

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Many attempts have been made to devise a satisfactory classification of the Gram-positive, catalase-positive cocci, but there is as yet no general agreement as to how the group can best be subdivided or what the subdivisions shall be called. Wilson and Miles (1955), for example, would recognize Staphylococcus, Micrococcus, Sarcina and Rhodococcus as separate genera, while Breed et al. (1948) defined 3 genera, Micrococcus, Sarcina and Gaffkya. Shaw, Stitt and Cowan (1951) on the other hand, regarded the whole group as being of one genus, Staphylococcus, and rejected the name Micrococcus as invalid.

In the course of an investigation into the chemical composition of the cell wall in Gram-positive bacteria, (Cummins and Harris, 1955, 1956) the results obtained suggested that cell wall composition was a useful taxonomic character. It seemed of interest therefore to analyse cell wall fractions from a number of strains of the staphylococcus-micrococcus group to see whether the results would be of any value in the classification of the group as a whole.

MATERIALS AND METHODS

Strains of Bacteria.

Of the 24 strains examined, 7 were isolated from nasal swabs in The London Hospital by Dr. F. C. O. Valentine. These comprised 3 strains of Staphylococcus aureus, 3 of S. albus, and 1 of S. citreus. These 7 strains were selected in the first place on the basis of colonial pigmentation; subsequent testing for coagulase production confirmed that the S. aureus strains were coagulase positive while the other four were negative. All other strains were obtained from the National Collection of Type Cultures.

Table I. Principal components in the cell walls of 24 strains of the staphylococcus–micrococcus group.

	Galactose	Glucose	Mannose	Unknown carbohydrate material	Glucosamine	Galactosamine	Unknown 'Hexosamine'	Alanine	Glutamic acid	Lysine	Glycine	Diaminopimelic acid
GROUP I.												
Staphylococcus aureus (3 strains)	-	-	-	-	+	-	+	+++	+++	+++	+++	
Staphylococcus aureus NCTC 7415	-	-	-	-	+	-	+	+++	+++	+++	+++	
Staphylococcus albus (3 strains)	-	-	-	-	+	-	+	+++	+++	+++	+++	
Staphylococcus albus NCTC 7944	-	-	-	-	+	+	+	+++	+++	+++	+++	
Staphylococcus saprophyticus NCTC 7292	-	-	-	-	+	-	+	+++	+++	+++	+++	
Staphylococcus saprophyticus NCTC 7291	-	Tr	-	-	+	-	+	+++	+++	+++	+++	
Sarcina ureae NCTC 4819	-	-	-	-	+	-	+	+++	+++	+++	+++	
Staphylococcus citreus (1 strain)	-	+	+	-	+	-	+	+++	+++	+++	+++	
Sarcina lutea NCTC 611	-	++	-	-	+	-	+	+++	+++	+++	+++	
Micrococcus luteus NCTC 8512 (ATCC 398)	-	++	-	-	+	-	+	+++	+++	+++	+++	
Micrococcus lysodeikticus NCTC 2665	-	++	-	-	+	-	+	+++	+++	+++	+++	

Micrococcus lysodeikticus NCTC 2665	-	++	-	-	+	-	+	+++	+++	+++	+++	

GROUP II.												
Micrococcus conglomeratus (NCTC 2677	++	+	-	-	+	Tr	+	+++	+++	+++		
Staphylococcus lactis NCTC 7564	++	+	-	-	+	Tr	+	+++	+++	+++		
Micrococcus roseus NCTC 7520	++	Tr	-	-	+	Tr	+	+++	+++	+++		
Aerococcus viridans NCTC 8251	-	+	+	-	+	+	+	+++	+++	+++		
Aerococcus viridans NCTC 7593	-	+	-	-	+	+	+	+++	+++	+++		
Aerococcus viridans NCTC 7592	+	+	-	-	+	+	+	+++	+++	+++		
Aerococcus viridans NCTC 7764	+	+	Tr	-	+	+	+	+++	+++	+++		
GROUP III.												
Micrococcus varians NCTC 7281	++	-	-	++	+	-	+	+++	+++		++	++
Micrococcus citreus NCTC 7731	++	-	-	++	+	-	+	+++	+++		++	++

Cultural Methods.

The organisms were grown on nutrient agar at 37°C for 24-48 hours, or, in the case of some more slowly growing strains such as Micrococcus conglomeratus (NCTC 2677) in nutrient broth in conical flasks, the volume of medium being adjusted to give good aeration. After harvesting, the suspensions were washed twice in distilled water and preserved in 0.5 per cent formol saline if not disintegrated at once.

Preparation and Analysis of Cell Wall Fractions.

The method of preparing cell wall fractions, and the chromatographic techniques used have been described in detail elsewhere (Cummins and Harris, 1956). Briefly, the organisms were disintegrated by shaking with glass beads (ballotini, 0.18-0.2 mm diam.), and the insoluble (cell wall) fraction separated by centrifugation and purified by digestion with trypsin and ribonuclease, followed by pepsin. Acid hydrolysates (100°C) of this material were examined by two-dimensional paper chromatography and the amino acids, sugars, and amino sugars identified. The amount of each component present was recorded as +++, ++, +, ±, Tr, or - depending on the size and intensity of the spots.

RESULTS

The results obtained in the 24 different strains examined are given in Table I. The findings in some of these organisms have already been reported (Cummins and Harris, 1956), but are included here for the sake of completeness. For each organism, data are presented concerning the occurrence of three separate groups of substances in the cell wall hydrolysates; amino acids, amino sugars, and sugars. For simplicity only the major components present are recorded in the case of the amino acids. In every instance these three or four major amino acid components accounted for a very high proportion of the total amino acids present in the preparations and they gave rise to clear cut and readily recognisable patterns. Small amounts of a number of other amino acids were also to be found in some of the preparations. The significance of these minor components is still uncertain and the problem has been discussed elsewhere (Cummins and Harris, 1956). It is possible that in some

cases they arise because the cell wall preparation had not been completely freed from extraneous proteins. In none of these preparations was any ribose identified, which indicates that they had been effectively freed from nucleic acid.

In our previous survey of the cell wall components of different types of Gram-positive bacteria it appeared that differentiation between large groups of organisms at the generic level was provided most clearly by the pattern of the major amino acid components. The pattern of the sugar and amino sugar distribution, on the other hand, appeared more to reflect differences between species or strains, although the occurrence of certain sugars such as arabinose in the corynebacteria and rhamnose in the streptococci probably has a broader significance.

The amino acid pattern was therefore expected in the present survey of Gram-positive cocci to reveal any large taxonomic divisions which might be present. In fact, it was found that the bacteria studied fell quite sharply into three main groups with respect to the pattern of the major amino acid components of the cell walls.

Group I.

Characteristic cell wall amino acids; alanine, glutamic acid, lysine, and glycine.

This is the largest group in the present series (15 out of 24 strains) and includes representatives of the species normally parasitic on man. Within the group the findings seem to suggest a division between the first 11 strains and the 4 remaining ones, in that the latter contain appreciably more sugar in their cell walls. Another possible point of distinction, omitted from Table I, is that the cell wall preparations from Staphylococcus aureus, S. albus, and S. saprophyticus contain small but appreciable amounts of serine whereas this is apparently absent from preparations of the other strains in Group I (see Cummins and Harris, 1956).

The results in the case of Micrococcus luteus (ATCC 398) are of some interest, since this strain has been proposed as the type species of the genus Micrococcus (Breed, 1952). The difference in cell wall composition between this strain and the strains of S. albus and S. aureus is in the presence or absence of hexose, and to judge by the results in the other genera (e.g., Streptococcus, Lactobacillus, and Corynebacterium) this would point to a difference in species but not

in genus, since they have the same characteristic cell wall amino acids. The results of cell wall analysis, therefore, so far as they go in this small series, do not support the separation of Micrococcus and Staphylococcus as distinct genera.

Group II.

Characteristic cell wall amino acids; alanine, glutamic acid and lysine; glycine absent or present only in traces.

The first 3 strains in this group (2677, 7564, and 7520) have cell wall compositions closely resembling one another, with considerably less galactosamine than glucosamine. The 4 strains of Aerococcus viridans, on the other hand, show considerable variation in the type and amount of hexose present, but all have galactosamine in approximately equal amounts in their cell walls.

Group III.

Characteristic amino acids; alanine, glutamic acid, α, ε-diaminopimelic acid, and glycine.

These 2 strains are unusual in that diaminopimelic acid has not been previously reported in Gram-positive cocci, and also because of the occurrence in their cell walls of an unidentified sugar component. This material has not been observed in any of the other strains or indeed in any other organism we have examined. It moves very slowly in phenol/water (Rf $\bar{c}$ = galacturonic acid), but more rapidly in lutidine (Rf $\bar{c}$ = galactose). It reacts with aniline hydrogen phthalate in a similar manner to the hexoses, but it fails to react with naptho-resorcinol and so presumably is not a uronic acid. It does not correspond in chromatographic behavious to any known monosaccharide and may well be an oligosaccharide "core" relatively resistant to hydrolysis. It is of interest that it should have been encountered only in the two organisms with a cell wall amino acid pattern different from that found so far in any other Gram-positive cocci.

Table II. Comparison of classification of 17 strains of staphylococci (Shaw, Stitt and Cowan, 1951) with the grouping of the same strains on cell wall composition.

Species name Shaw, Stitt and Cowan 1951	NCTC number	Group by cell wall composition (see Table I)	Other names for strains
Staphylococcus aureus	7415	I	Staphylococcus epidermidis
Staphylococcus saprophyticus	7292	I	Staphylococcus epidermidis
	7291	I	Staphylococcus albus
Staphylococcus lactis	7944	I	Staphylococcus albus
	2677	II	Micrococcus conglomeratus
	7564	II	
	7281	III	Micrococcus varians
Staphylococcus roseus	7520	II	Micrococcus roseus
Staphylococcus afermentans	7731	III	Micrococcus citreus
	4819	I	Sarcina ureae
	2665	I	Micrococcus lysodeikticus
	8512	I	Micrococcus luteus
	611	I	Sarcina lutea
α-group	8251	II	
	7593	II	Aerococcus viridans
	7592	II	(Williams, Hirsch and
	7764	II	Cowan, 1953)

DISCUSSION

The results reported here indicate that it is possible to divide the Gram-positive catalase-positive cocci into at least 3 well-defined groups on the basis of cell wall composition, but these do not correspond to the subdivisions suggested in any recent classification of these organisms. We were able to include in the 24 strains examined, 13 representatives of the 5 species of Staphylococcus proposed by Shaw, Stitt and Cowan (1951) and also 4 strains of their α-group, later named Aerococcus viridans (Williams, Hirch and Cowan, 1953). The results of cell wall analysis on these 17 strains are shown in Table II, and it is evident that there is no agreement between the two methods of subdivision. This is particularly noticeable in the case of the strains labelled Staphylococcus lactis, at least one of which falls into each of the 3 cell wall groups.

We do not wish in this paper to suggest a new classification of the staphylococcus-micrococcus group, nor to criticise (or support) any of the existing ones, but to bring to the notice of those interested in taxonomic problems a bacterial character which may be of value in this field. The use of cell wall composition as a taxonomic character in Gram-positive bacteria has been discussed elsewhere (Cummins and Harris, 1956). The arguments there put forward in its favour are, briefly, that the composition of the cell wall seems to be quite unaffected by growth conditions, that the components present can be identified by comparison with artificial standards and that where differences in the pattern of amino acid components occur, these differences are large and clear-cut. No character, however, can have such overriding significance that all others must give way to it, and the final taxonomic value of cell wall composition has yet to be determined.

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THE CLASSIFICATION OF LOWER ORGANISMS

Nomenclatural Review

Copeland, Herbert Faulkner. The Classification of Lower Organisms. Pacific Books. Palo Alto, California. pp. ix, 302. 1956

The Linnaean assumption that all living things may be allocated either to the plant kingdom or to the animal kingdom has been challenged on a number of occasions. Proposals were early made that the relatively simple forms, including the Protozoa and Protophyta, might well be combined into a third kingdom distinct from Plantae and Animalia. Among the names used have been Protoctista (Hogg, 1860), Primalia (Wilson and Cassin, 1864) and Protista (Haeckel, 1866). Copeland agrees with certain recent writers that four kingdoms should be recognized.

The author states that "the purpose of this work is to persuade the community of biologists that the accepted primary classification of living things as two kingdoms, plants and animals, should be abandoned; that the kingdoms of plants and animals are to be given definite limits, and that the organisms excluded from them are to be organized as two other kingdoms." He names and defines the four kingdoms as follows:

Kingdom I. Mychota Enderlein, 1925. (Protophyta Haeckel, 1894; Monera Copeland, 1938; Anucleobionta Rothmaler, 1948). Organisms without nuclei; the bacteria and the blue-green algae.

Kingdom II. Protoctista Hogg, 1860. Protozoa Haeckel, 1894; Protista Copeland, 1938; Protobionta Rothmaler, 1948). Nucleate organisms not of the characters of plants and animals; the protozoa, the red and brown algae and the fungi.

Kingdom III. Plantae (Metaphyta Haeckel, 1894; Cormobionta Rothmaler, 1948). Organisms in whose cells occur chloroplasts, being plastids of a bright green color, containing the pigments chlorophyll a, chlorophyll b, carotin and xanthophyll, and no others; and which produce sucrose, true starch, and true cellulose.

Kingdom IV. Animalia. (Metazoa Haeckel, 1894; Gastrobionta Rothmaler, 1948). Multicellular organisms which

pass during development through the stages called blastula and gastrula; typically predatory, and accordingly consisting of unwalled cells and attaining high complexity of structure and function.

We are concerned in this review only with the kingdom Mychota defined to include the bacteria and the blue-green algae. As noted above, the distinctive character ascribed to the members of this kingdom is the absence of a nucleus. The nucleus is defined as follows:

"Morphologically the nucleus is a part of a protoplast which is set apart by a membrane and which originates ordinarily by a division of a pre-existing nucleus in the manner called mitosis. In this process, a definite number of definite chromosomes appear and undergo equal division."

The author senses the difficulty in an unqualified statement that these organisms lack nuclei. He says:

"In describing the Mychota as lacking nuclei, one commits himself to one side of a controversy of many years duration. Because of the greater size of the cells of the blue-green algae, the facts are more easily ascertained in this group than in the proper bacteria."

The latest cited authority on the cytology of the blue-green algae is Haupt (1923), who emphasized "the impropriety of calling any part of these cells a nucleus." Copeland states further, "Recent studies of typical bacteria by conventional microtechnical methods and by the electron microscope have made it possible to recognize the essential identity of the structure of their cells with those of the blue-green algae."

To the writer the proof of the presence or absence of a nuclear membrane as a criterion of the presence of a nucleus is rather beside the point. Are there bodies within the cells of the bacteria which perform the essential functions of chromosomes in the mechanism of heredity? The evidence of recent years has accumulated to the point where there is little remaining doubt the answer is yes, and that within the bacterial cell there is a body which functions much as does the nucleus of a higher plant or animal. The author

tacitly admits the existence of this fundamental difficulty in his scheme of classification. The evidence certainly does not warrant the separation of the bacteria from other plants on the basis of the postulated lack of a nucleus in the cell. It would seem that the intergradations between the blue-green algae and the bacteria would warrant the assumption of interrelationship, but with no good reason to place them in a separate kingdom. Thimann (1955), in his text on microbiology states the case as follows:

> "Whether or not bacteria possess a nucleus has been a subject of discussion and argument for forty years and has only been settled (in the affirmative) relatively recently." Also, "Taking the observations as a whole, there can be no doubt that bacteria possess one or two nuclear granules or chromosomes."

Notwithstanding disagreement with Copeland's thesis, there is much of nomenclatural and taxonomic interest in his discussion of the Mychota. He writes:

> "It is the right and duty of every person who thinks that the taxonomic system can be improved to propose to change it. A salutary convention requires that proposals in taxonomy be unequivocal; one proposes a change by publishing it as in effect; it comes actually into effect in the degree that the generality of students of classification accept it."

The author follows Oparin (1938) in his concept of the situation on the earth when life began, in water saturated with the gases ammonia and methane of which the atmosphere presumably consisted. "These theories indicate, as the most primitive form of life which has been able to survive, the anaerobic bacteria." How anaerobes could secure their growth energy from the components of the primitive atmosphere as specified is not stated. The conclusion is reached "Life requires energy" and "Under anaerobic conditions, an organism can obtain energy by converting sugar to alcohol, but it cannot use alcohol as a source of energy." In fact, however, there are bacteria that, under anaerobic conditions in a suitable environment, can utilize alcohol as a source of energy.

"The existence of organisms without nuclei shows that the nucleus evolved after life did; it did not evolve at the same time as the protoplasm." If the modern work on the viruses is to be trusted it would seem quite as probable that nuclear material and the essential components of the nucleus evolved at least as soon as the protoplasm.

Copeland's Chapter II is "An Essay on Nomenclature." That there are three Codes of Nomenclature, Botanical, Zoological, and Bacteriological, is pointed out. Quite appropriately it is emphasized that the very existence of three sets of rules and their continual amendment is "evidence of imperfection." He then points out "certain anomalies in the codes as they stand." The Zoological Rules term the second component of the name of a species a specific name. Copelant insists that the principles of grammar are violated by "treating specific epithets as names." The sapiens of Homo sapiens is not a name of man, nor is the adjective vulgare in Hordeum vulgare the name of barley. The name of a species is a binary combination. Botanists and bacteriologists use the phrases "species name" and "specific name" synonymously, and designate the two components the generic name and the specific epithet, respectively.

The author also calls attention to the fact that in zoology all family names end in -idae and all subfamily names in -inae. These are plural feminine adjectival endings, and should agree with the name of the kingdom. Animalia is a plural neuter noun. He suggests that these endings were first used for the families of the birds (Aves, fem. pl.), and the family names are unobjectionable in this group, but quite inappropriate in a kingdom Animalia.

He criticizes the Botanical Code in that it enunciates a series of principles followed by a list of rules which in some cases prescribe procedures not warranted by the preceding principles. He regards the list of conserved and rejected names (covering about 70 pages) as fixed quite irrespective of principle. He concludes that current botanical nomenclature "is to a considerable extent governed by enactments of the nature of ex post facto laws and bills of attainder."

The author very neatly points up the difficulty of getting nomenclatural cooperation with zoologists. The Bacteriological Code provides that a bacterial generic name is illegitimate if it is a later homonym of the name of a genus of

the protozoa. Copeland notes that this is a unilateral arrangement: "The avoidance of homonyms which they desire will not, however, be attained; no zoologist will allow a new name for the flagellate Klebsiella on account of an earlier Klebsiella among bacteria." This is probably true at present. The great tragedy of biological nomenclature is that the botanists and zoologists have made no real effort to harmonize the wholly indefensible incompatibilities of their present codes. Why should the editors and users of Biological Abstracts be compelled to obey three different codes, sometimes all three in a review of a single article? The differences in the codes are usually not great, but they are sometimes highly annoying.

Copeland reasons that by formation of two new kingdoms "a nomenclature of superior legitimacy can be applied in groups treated as removed from jurisdiction of the rules." He then proceeds to "a brief formulation of those principles, appealing to reason and proven sound in practice, to which all nomenclature must conform."

The first of these principles (not differing in essentials from that of each of the three nomenclatural codes) is spelled out in refreshing detail.

> "Scientific names are words of the Latin language. They are not 'of Latin form' or 'construed as Latin;' they are Latin. This is to treat Latin as a living language and scientific names as subject to the rules of its grammar."

Altogether seven principles are laid down, none of them differing essentially from those found in all three codes.

One statement is well worth considering. It is not found in any code at present but could advantageously be included in that of the bacteriologists. It reads:

> "It follows from the principle of the binomial nomenclature of species that no genus is named until one or more of its species are designated by binomial names."

The reviewer would go a step further and make clear that a generic name given by an author without designation or indication of the names of one or more contained species, even though validly published, is illegitimate, and should so remain until a species in the genus has been named by a subsequent author.

Copeland's prescription for capitalization of specific epithets accords with the earlier Botanical Codes, but with none of the recent revisions of any of the codes.

The discussion of the use of plurals of generic names is internally inconsistent. The author states "Plurals of generic names are not tenable" and then proceeds to show how they may be used properly. "Ericae means the species of the genus Erica." He points out, quite correctly, that such a plural should never "be used to designate the genus together with its allies."

However, the author gets on untenable ground when he says: "Names consisting of words other than generic names modified by terminations signifying 'resembling' or 'of the group of' are not tenable, because they are nonsense." He illustrates by use of Engler's name Coniferinae applied to a class objectionable because the Latin word conifer is an adjective, and Coniferinae would presumably mean "resembling cone-bearing." But there are many Latin nouns which end in fer. A standard-bearer is a signifer or an aquilifer, while vexillifer (standard-bearing) is an adjective. Conifer in modern Latin can be a noun, cone-bearer, and Coniferinae mean "those resembling cone-bearers."

Copeland analyzes correctly the significance of -aceae as a family ending in the kingdom Plantae. Such family names are "adjectives in the feminine, agreeing with the name of the kingdom Plantae." He insists (appropriately) that names of orders, families, etc., of bacteria (usually placed in the kingdom Plantae) should, when placed in the kingdom Mychota, have the endings modified to indicate that they are adjectives modifying a plural neuter noun (Mychota). Ordinal names should end in -alea instead of -ales, and family names in -acea rather than -aceae. To the reviewer it seems probable that the author is correct in some and in error in others of the suggested changes. The Latin endings -aceus, -acea, -aceum (singular); -acea, -aceae, -acea (plural), give the feminine Latin plural -aceae (as in Corynebacteriaceae) and the neuter plural in -acea (Corynebacteriacea). Copeland relabels about 60 families newly named or transferred to Mychota. He also changes the ordinal ending -ales to -alea in transferring from Plantae to Mychota. The Latin endings -alis, -alis, -ale (singular), -ales, -ales, -alia (plural), give feminine Latin plurals in -ales (Actinomycetales) and neuter plurals in -alia (not

-alea)(Actinomycetalia). The ending -alis comes under the Latin rules of declension of adjective stems in -i of two endings. Five ordinal names should be correctly spelled Actinomycetalia, Caulobacteralia, Myxobacteralia, Sphaerotilalia, and Spirochaetalia. The family names Achromobacteracea, Azotobacteracea, Acetobacteracea, Nitrobacteracea, Caulobacteracea, and Myxobacteracea are misspelled by Copeland, there is no i in the family ending -acea and none in the stem ending.

Five new families are named and described: Kurthiacea, Pasteurellacea, Chromatiacea, Rhodobacillacea, Chlorobiacea.

SUPRAGENERIC TAXA IN THE KINGDOM MYCHOTA

I. Kingdom Mychota Enderlein.
  A. Phylum Archezoa Haeckel.
    1. Class Schizophyta (Cohn) McNab.

      a. Order Schizosporea Cohn. 13 Families. Micrococcacea Pribram; Neisseriacea Prévot; Corynebacteriacea Lehmann and Neumann; Rickettsiacea Pinkerton; Kurthiacea fam. nov.; Bacillacea Fischer; Achromobacteracea Breed; Pasteurellacea fam. nov.; Rhizobiacea Conn; Azotobacteracea Bergey, Breed and Murray; Spirillacea Migula; Acetobacteracea Bergey, Breed and Murray; Nitrobacteracea Buchanan.

      b. Order Actinomycetalia Buchanan. 1 Family. Mycobacteriacea Chester.

      c. Order Caulobacteralia Henrici and Johnson. 2 Families. Leptotrichacea Schroter; Caulobacteracea Henrici and Johnson.

    2. Class Myxoschizomycetes Schaffner.

      a. Order Myxobacteralia Clements. 5 Families. Cytophagacea Stanier; Archangiacea Jahn; Sorangiacea Jahn; Myxobacteracea E. F. Smith; Myxococcacea Jahn.

b. Order Spirochaetalia Buchanan. 2 Families. Spirochaetacea Swellengrebel; Treponematacea Robinson

3. Class Archiplastidea Bessey.

a. Order Rhodobacteria Molisch. 3 Families. Chromatiacea (Migula) nom. fam. nov.: Rhodobacillacea nom. nov.; Chlorobiacea nom. nov.

b. Order Sphaerotilalia nom. nov. 1 Family. Shpaerotilacea Pribram.

c. Order Coccogonea Campbell. 2 Families. Chroococcacea (Nägeli) Rabenhorst; Achromatiacea Buchanan.

d. Order Gloiophycea Rabenhorst. 10 Families. Oscillatoracea Harvey; Beggiatoacea Migula; Chamaesiphonacea Borzi; Nostocacea (Nägeli) Rabenhorst; Scytonematacea Rabenhorst; Chlamydotrichacea Pribram; Rivulariacea Rabenhorst; Sirosiphonacea Rabenhorst; Pleurocapsacea Geitler; Crenotrichacea Hansgirg.

Copeland ends his discussion: "Such are the Mychota, the organisms which may be characterized as lacking nuclei."

As is evident from the above outline, Copeland's arrangement of the bacteria differs quite materially from that of most recent authors. For example, the inclusion of Rickettsiacea between genera as unlike as Corynebacterium and Bacillus among the true bacteria is quite in contrast to recent tendency to emphasize their intermediate position between the bacteria and viruses.

Apparently the several new taxa named and described are validly published. Their incorporation into conventional bacteriological taxonomy will require some emendation of spelling of suprageneric taxa.